Co-registration of Intravascular Ultrasound and Angiography

Andrew Cassar1, Megha Prasad1, Kenneth A. Fetterly1, Abhiram Prasad1

Background: Intravascular ultrasound (IVUS) provides cross sectional imaging of coronaries but lacks overview of the vascular territory provided by angiography. We studied the feasibility of automated co-registration of angiography and IVUS to facilitate interrogation of the two imaging modalities in a synchronous manner.

Methods: 49 consecutive patients undergoing surveillance for cardiac allograft vasculopathy with angiography and IVUS of the left anterior descending artery (LAD) were enrolled. A pre-IVUS angiogram of the LAD was performed followed by an ECG triggered fluoroscopy (ECCFT) during IVUS pullback (Eagle Eye Platinum – Volcano Corp.) at 0.5mm/s using an automatic pullback device. ECCFT was used to track the IVUS catheter during pullback and establish a spatial relationship to the pre-IVUS angiogram. Angio-IVUS co-registration was performed with a research prototype (Siemens Healthcare, Germany) and accuracy evaluated by distance mismatch between angiography and IVUS images at vessel bifurcations (Figure A).

Results: The median (IQR) co-registration distance mismatch measured at 108 bifurcations in 42 (85%) patients was 0.35 (0.00-1.16) mm (Figure B). 7 patients were excluded due to inappropriate data acquisition (n=3) and failure of tracking (n=4) e.g. due to overlapping sternal wires. Estimated effective radiation dose for ECCFT was 0.09 mSv.

Conclusions: This study demonstrates the feasibility of angio-IVUS co-registration which may be used as a clinical tool for localizing IVUS cross sections along an angiographic roadmap.

Supporting File(s): abstracts/abs_1794/pic_for_pub.jpeg

TCT-647

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Impact of visit-to-visit variability of blood pressure and coronary atheroma changes by 3-D IVUS and subsequent cardiovascular events

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Background: Visit-to-visit variability in systolic blood pressure (SBP) was reported to be associated with increased cardiovascular risk. Intravascular ultrasound (IVUS) is used as an end point in studies aimed at reducing progression or regression of coronary atheroma. However, the relationship between variability in blood pressure and atheroma volume changes by IVUS, or long-term clinical outcomes has been poorly defined.

Methods: Serial IVUS examinations were performed in 338 stable angina pectoris patients undergoing percutaneous coronary intervention (PCI). After PCI for de novo or restenotic lesions, intravascular ultrasound (IVUS) was performed in their non-culprit vessels at baseline. At 12-16 months, IVUS of the originally examined coronary artery was performed during follow-up angiography. Five-year clinical outcomes, including major adverse cardiac and cerebrovascular events (MACCE), and annual progression rate of atherosclerosis by volumetric IVUS, and visit-to-visit variability in SBP for five-years were evaluated.

Results: Atheroma volume increase by IVUS was 5.7%, and five-years MACCE rate was 22.6%. Patients with MACCE had larger annual atheroma progression than the rest of the population (20.6% vs. 2.3%, P<0.001). Visit-to-visit variability in SBP was a strong predictor of subsequent increased coronary atheroma volume (eg., top-decile hazard ratio (HR) for SD SBP over five visits: 4.18, 95% CI 1.95-8.67, p<0.01), independent of mean SBP, but dependent on precision of measurement (top-decile HR over five visits: 4.21, 2.58-7.64, p<0.01). Maximum SBP reached was also a strong predictor of MACCE (HR for top-decile over five visits: 8.12, 3.46-10.11, p<0.01, after adjustment for mean SBP). In addition, residual visit-to-visit variability in SBP of maximum SBP was also a strong predictor of increased coronary atheroma volume and MACCE (top-decile HR for MACCE: 4.49, 1.92-6.48, p<0.01).

Conclusions: Visit-to-visit variability in SBP and maximum SBP are strong predictors of increased coronary atheroma volume, independent of mean SBP. Increased residual variability in SBP in patients with treated hypertension is associated with a high risk of subsequent cardiovascular events.

TCT-650

The high sensitive C-reactive protein (hs-CRP) level represents the disease burden and the age but not vulnerability of coronary atherosclerosis: a study of volumetric plaque composition by 3-vessel virtual histology-intravascular ultrasound

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Background: hs-CRP has been known as a systemic inflammatory marker of atherosclerosis and considered as one of the predictors of future cardiac events. Some reports presented hs-CRP level was associated with plaque vulnerability but most studies were performed by assessing focal target plaque but not whole plaques from a coronary tree. Methods: To evaluate the relationship of plasma hs-CRP level and volumetric plaque composition of the coronary arterial tree, we performed 'whole vessel' virtual histology-intravascular ultrasound (IVUS-IVUS) in 189 vessels of 63 patients. The components of atherosclerosis were classified as fibrous (FI), fibrous-fatty (FF), fatty (FT), and calcific (CAL). Results: hs-CRP level was significantly correlated with the percentage of calcific plaque content (ρ = 0.36, p=0.002), nl-ncVHTCFA (ρ = 0.36, p=0.002), and MLA (ρ = 0.31, p=0.009) but not with the percentage of fibrous plaque (ρ = 0.20, p=0.009). In a multivariable model, the extent of both lipidic and necrotic plaque independently associated with segmental vasoconstriction (β =1.2, p=0.023; β =0.9, p=0.027).

Conclusions: Following NSTE-ACS, both lipidic and necrotic plaque content each associate with segmental endothelial dysfunction, providing a mechanistic link among atheroma composition and lumen reactivity, and thus potential 'vulnerability' for a clinical event.
necrotic core (NC) and dense calcium (DC). Quantitative assessment of these plaque components and the presence of VH-IVUS-derived thin-cap fibroatheroma (VH-TCA) in the coronary arterial trees were compared to hs-CRP levels in individuals. hs-CRP levels were measured before coronary angiogram and IVUS study.

Results: Forty-nine patients (77.8%) were diagnosed with acute coronary syndrome (ACS). In culprit lesion, there was a positive correlation between hs-CRP levels and mean plaque burden, total plaque volume index, volume index of FF and DC. But parameters of NC and the number of VH-TCFA were not related with hs-CRP level. In multivariate analysis, the volume index of DC was most reliable factor to hs-CRP (β=0.449, 95% CI= 0.072-0.908, p<0.001).

Conclusions: This three-vessel IV-IVUS presented that hs-CRP were related to the total atherosclerotic burden and the age (coronary calcium) but not vulnerable features (NC or VH-TCA) of plaques in coronary arterial tree. Increased hs-CRP level as a biomarker to predict cardiovascular events might imply atherosclerosis severity of whole coronary tree but not current plaque vulnerability.

TCT-652

Longitudinal Distribution of Endothelial Shear Stress Along Culprit Lesions and Association with Plaque Characteristics in Patients with Acute Coronary Syndromes: A Three-Dimensional Frequency-Domain Optical Coherence Tomography Study


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Background: Plaque rupture/thrombosis is the most prominent mechanism leading to acute coronary syndromes (ACS). However, the factors responsible for the location of plaque rupture/thrombosis along a lesion are unclear. Endothelial shear stress (ESS) is a major determinant of vascular pathology. We investigated the local ESS patterns in association with the distribution of thrombus/plaque features along the culprit lesions in patients with ACS prior to percutaneous coronary intervention using frequency domain optical coherence tomography (FD-OCT).

Methods: 3-dimensional coronary artery reconstruction using FD-OCT & coronary angiography was performed in the culprit vessel of 8 patients presenting with ACS. In each culprit lesion, we assessed local ESS (with computational fluid dynamics) and morphologic features (by FD-OCT) in consecutive 1-mm segments distinguished in a proximal, mid and distal part. As thrombus interferes with accurate evaluation of underlying plaque characteristics, plaque disruption and local thrombus were combined in the analysis.

Results: Six lesions (75%) had significant stenosis (>50% area stenosis by OCT). ESS was elevated in the mid part of the lesions (normalized ESS using the average within each lesion: proximal 0.7±0.2 vs distal 1.3±0.1 vs distal 0.4±0.2; p<0.01). Mid parts also had increased lipid arc (proximal 129±20° vs middle 187±19° vs distal 136±18°; p<0.01) with a higher incidence of plaque disruption/thrombus (proximal 8% vs middle 29% vs distal 14%; p=0.071). In segments with plaque disruption/thrombus, ESS was higher (normalized ESS: 1.3±0.2 vs. 0.9±1.0; p=0.17), lipid arc was greater (23±19.5 vs 150±13.5°; p<0.01), and fibrous cap was thinner (108±24 vs 106±31 jum; p<0.05).

Conclusions: In patients with ACS, the highest ESS values within a culprit lesion were localized with plaque disruption/thrombus, which were more common in the mid part of the lesions. Further studies are warranted to elucidate whether ESS directly acts as a trigger for plaque rupture or whether other factors are involved in the rupture/thrombosis of a plaque which developed in a preceding low ESS environment.

TCT-653

An Intracoronary Near-infrared Spectroscopy Signature of Culprit Lesions in Non-ST-Segment Elevation Myocardial Infarction

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Background: A recent near-infrared spectroscopy (NIRS) study showed culprit lesions in ST-segment elevation myocardial infarction (STEMI) are frequently characterized by a maximum lipid core burden index in 4-mm (maxLCBI4mm) >400. The frequency of this finding in non-STEMI (NSTEMI) culprit lesions is unknown.

Methods: We analyzed consecutive NSTEMI patients undergoing combined NIRS and intravascular ultrasound prior to stent placement in the US and Sweden. The culprit segment was defined as the 10-mm distal to the proximal angiographic culprit margin. The remaining vessel was divided into contiguous 10-mm non-culprit segments. The primary measure of interest was maxLCBI4mm in culprit and non-culprit segments.

Results: Results: Among 40 NSTEMI patients (age 68±13; 65.0% male) 215 coronary segments were analyzed. Whereas maxLCBI4mm>400 was detected in only 7.3% of non-culprit segments, maxLCBI4mm>400 was found in 59.5% of culprit segments (p<0.0001, sensitivity 59.5%, specificity 92.7%, Figure A). Culprits had a 5.8-fold greater maxLCBI4mm compared to non-culprits (median [interquartile range] 427 [270,564] vs 73 [0,247], p<0.0001). Within the culprit artery, NIRS accurately distinguished culprit from non-culprit segments (receiver operating characteristic analysis area under the curve=0.84, Figure B).

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